TREASURY DEPARTMENT
UNITED STATES PUBLIC HEALTH SERVICE
HUGH S. CUMMING, SURGEON GENERAL

PUBLIC LIBRARY
1925
DETROIT, MICH.

THE TRANSMISSION OF DISEASE BY FLIES

BY

ERNEST A. SWEET
Passed Assistant Surgeon
United States Public Health Service

SUPPLEMENT No. 29
TO THE
PUBLIC HEALTH REPORTS
APRIL 14, 1916
[REVISED EDITION, JUNE, 1922]

WASHINGTON
GOVERNMENT PRINTING OFFICE
1925

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
10 CENTS PER COPY

THE TRANSMISSION OF DISEASE BY FLIES

Insects play a definite rôle in the transmission of disease, a fact which has been conclusively demonstrated over and over again. Many of the most serious ills of man are conveyed from person to person through the medium of mosquitoes, flies, lice, ticks, and other forms of vermin. How the transmission of disease is effected, the particular insects acting as carriers, and the means of combating such pests have all become matters with which the public is concerned.

Recently it has been possible to convict the fly of many of the crimes and misdemeanors of which it is guilty. We now know that flies, instead of being harmless insects, of moment only when they invade our food supplies, are in reality highly dangerous, and that a single fly may be responsible for the development of typhoid fever or other illness of a serious nature.

Kinds of Flies

There are many kinds of flies, not all of which have the same structure, habits, or methods of reproduction. In a general way, however, the families resemble one another, and while the following description applies principally to house flies, with slight modifications it is applicable to other allied species as well.

The most common and widely distributed of all flies is the house fly. This insect is ordinarily present in all parts of the world and lives in practically any climate adapted to man. Nine-tenths of the flies found within or near dwellings belong to this group, although a number of other species so closely resemble house flies in appearance that differentiation may be impossible by other than experts. The favorite haunt of the house fly is the dwelling of man, and it is seldom found away from human habitations.

The bluebottle, or blow fly, is a second familiar species, owing to the characteristic and disturbing noise made in its flight. It has a strong liking for the exposed surfaces of fresh meat and fruits, the former seemingly having a powerful attraction for the insect.

Bearing a strong resemblance to the bluebottle fly is the greenbottle fly, which is slightly smaller and metallic green in color. It it commonly found near putrefying flesh, such as dead animals, excreta, and similar filth. A member of this group often breeds in

the excrement on the backs of sheep, the larvæ or maggots developing and feeding thereon, resulting in a serious pest to flockowners. When the larvæ mature in either filth or flesh they are especially voracious and consume a large part of the substance on which they are developing. The fact that insects of this family alternate between human excreta and food products renders them especially dangerous, although their number is usually limited and they are seldom satisfied to remain within doors.

One of the most important species is the stable fly, or, as it is sometimes called, the "biting stable fly." It is less often found in filth than the other varieties, but owing to the fact that it is a bloodsucking fly, opportunity for the direct inoculation of persons and animals with the organisms of disease is presented. It is this insect which has been incriminated in the spread of anthrax. The stable fly is about the size of the common house fly and resembles it in appearance, being gray in color and somewhat more stoutly built. Its proboscis, however, is of an entirely different character, as campers and others can testify, being arranged for penetrating and sucking. It frequently torments horses and cattle and may even cause detriment to stock through its activities. The insect is widely distributed. Closely allied to the stable fly is an African species known as the tsetse fly, which is responsible for the spread of sleeping sickness, a fatal infection found in certain regions of the African Continent.

The "lesser house fly" is the name given to a species which, next to the house fly, is the most common indoor resident. Probably everyone has observed the useless and apparently aimless, jerky flight of this insect beneath some suspended articles, such as a chandelier. This fly is an early visitor, usually being found before the common house fly is present in large numbers. Its breeding habits are the same as those of the house fly, but as it feeds less diligently and seldom alights, it is somewhat less objectionable. It strongly resembles the house fly but is slightly smaller and more slender, being, perhaps, better adapted to flight. The larval form of this fly is easily distinguished from that of the common house fly, as it is covered with spines.

In addition to the species enumerated, many other bloodsucking and nonbloodsucking species are of interest. The cheese fly deposits its eggs in cheese or fatty material, producing the so-called cheese skippers. The dung and the yellow dung flies and the latrine fly are so named because they develop in the excrement of animals or man. The fruit fly, a much smaller species than any of those mentioned, hovers about fruit juices, cider barrels, and like situations, being often found in the dregs of wine. None of these species, however, is as important as the common house fly.

Structure

The parts of the fly are the head, thorax, and abdomen. The head is connected with the thorax by a narrow neck which permits of rather wide movement. The greater part of the head is occupied by the eyes, some several thousand in number, described as compound. Between the compound eyes and near the top of the head is a triangular arrangement of three simple eyes. The upper two are much farther apart in the female than in the male, thus serving to easily differentiate the sexes. In spite of the arrangement of the eyes and the great mobility of the head, it is not believed that the vision of flies is especially acute, although the range of vision is wide. The sense of smell, however, is highly developed.

The proboscis protruding from the under and back part of the head is the most interesting part of the fly. When the insect is at rest, the proboscis is folded against the head, but upon alighting it is protruded through the mechanical action of certain air sacs.

Capping the end of the proboscis are two oval projections or lobes forming an opening leading into the mouth. The oral lobes in the house fly entirely prevent penetration of the skin by the proboscis therefore this particular species is in no sense a biting fly. Biting invariably constitutes positive proof that the insect is not a house fly, however much it may resemble that species. On the under and inner sides of the oral lobes are grooved channels which lead into the mouth. When these channel-like surfaces are placed in contact with liquids, suction is performed by the pharynx and the substance is drawn into the œsophagus, to be continued through the narrow neck into the thorax. If the food is solid it must first be dissolved through the action of saliva secreted by the salivary glands or reduced to very minute particles.

The greater part of the thorax is occupied by the muscles used in flying, these being placed above the stomach. Connecting with the œsophagus after it passes into the chest is a small duct leading to a dilation within the abdomen known as the crop. From this receptacle food is frequently regurgitated, appearing at the mouth parts in the form of small globules, to be again devoured at the insect's leisure. It is this habit of regurgitation, or vomiting, which renders flies extremely objectionable from a sanitary standpoint, particularly as the stomach contents are obtained in most instances from filth and garbage.

Several segments make up the abdomen or afterportion of the body, the number varying with the sex and species. The last four segments in the female form the ovipositor. Owing to its telescopic character, this organ may be partially withdrawn within the abdomen or extended when in the act of depositing the eggs. In this manner

eggs are laid in cracks and crevices or deposited beneath the surface of filth, thus affording excellent harborage for the larvæ. During the breeding season, which continues throughout the summer months, the abdominal cavity of the female is densely packed with eggs.

The wings are attached to the thorax and are marked by dark lines or veins extending through the wing membrane, the markings varying with the different species. There are three pairs of legs, all rather thickly covered with hair. Both the legs and wings are admirably adapted to the mechanical transference of substances with which they come in contact. It is this interchange of material, derived in many instances from polluted and filthy sources, which constantly exposes man to the danger of disease.

Reproduction

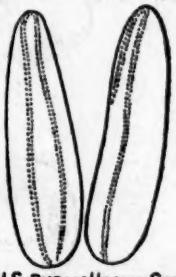
Flies are extremely prolific. The stages in the life cycle occupy at the most but a few days, and sexual maturity is reached within three or four days from the date of birth. As the eggs deposited by the female usually number a hundred or more, an enormous increase in the fly population is possible within a short period of time. Like many other insects, flies pass through several development stages, the immature forms differing radically from the adult. There are four stages in the development cycle, namely, the egg, then the larva or maggot period, next the pupa, chrysalis or resting stage, and finally the adult fly.

Nearly all flies breed in organic filth. A favorite medium is horse manure, but decaying vegetables, fermenting kitchen refuse, human excreta, and putrefying animal matter offer sites which are nearly as well adapted to the conditions necessary for propagation. The barn manure pile may be the place of origin of thousands of flies, the unprotected and unscreened privy serves as an excellent nidus for their growth, while fermenting foodstuffs and other waste food products scattered about the yard may also assist in their propagation. But three conditions are necessary for fly propagation in filth of this character, namely, proper temperature, moisture, and food supply. The warm manure pile and the decaying and fermenting garbage heap admirably fulfill these conditions. The swarm of flies invariably seen about places of this character during the summer season is an indication that not only feeding but actual propagation is in process.

The breeding season varies with the climate, usually beginning during May in the North, but more often in early April or March in the South; propagation continues until late September. The fly population is usually greatest during August and September, after which it very rapidly diminishes.

The eggs of the common house fly are smooth, white, glistening bodies about a twentieth of an inch in length, oval in shape and slightly broader at one extremity than the other. They are usually found in irregularly massed batches, each female depositing several such aggregations during her lifetime. The long ovipositor enables the female to deposit the eggs in crevices or beneath the surface of filth where the desiccating action of the atmosphere is less pronounced. Ordinarily a period of but 12 hours is required from the time the eggs are deposited until they are transformed into larvæ, although if the temperature is not favorable, two, three, or more days may be necessary. Hatching merely consists of the splitting of one extremity of the egg sac and the emerging of the larvæ.

The larvæ, or maggots as they are commonly known, represent the second stage in the development of the fly. They are about twice the size of the eggs but of much the same color and shape, the body being somewhat indistinctly segmented. There are no legs; nevertheless, by aid of the mouth parts and rudimentary enlargements on the under surface of the body the larvæ are actively motile and may travel a considerable distance. During the course of their growth they pass through two moults, constantly feeding upon the substance in which they are contained and reaching maturity in from three to six days. The larvæ exhibit a tendency to congregate in a zone just beneath the surface of the mass upon which they are developing, seldom being found directly upon the surface. After arriving at maturity they migrate or leave the substance where they commenced their growth, burrowing into the soil or even traveling a distance of several feet over the ground. This migration must always be considered and guarded against when fly-eradicative measures are instituted.



Eggs of house fly, greatly enlarged. (After Hewitt.)

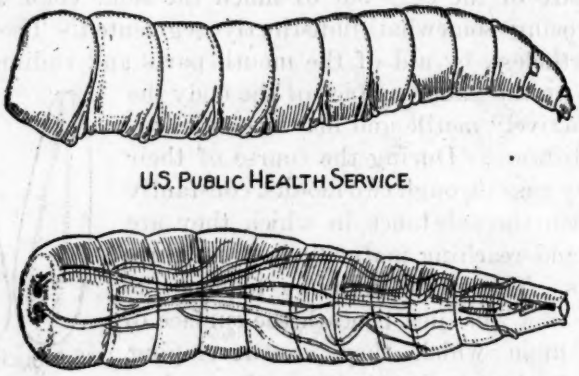
When the fly reaches the third or chrysalis stage of its development it is known as the pupa. This period is characterized by a contraction of the body, a change to a darker color, and a disintegration of the larval parts, with a corresponding growth of the wings and other structures of the future fly. The pupal stage ordinarily continues for about three days, when the adult and fully-grown fly emerges from the sac. After exposure for a short time the integument hardens, the wings dry, and the insect is ready for flight.

Under average conditions the entire cycle of development from egg to adult fly occupies a period of only from 8 to 10 days, but the time may be prolonged under unsuitable conditions of temperature

or food supply to 20 days or more. When the eggs are deposited upon nonfermenting vegetable matter, the period may also be somewhat lengthened, but the instinct of the female invariably leads her to place her eggs in the most favorable locality. The important consideration is, however, the ordinary developmental period, from 8 to 10 days. Manure, filth, or garbage which has been exposed for a longer period than one week is almost sure to breed flies. The removal of such filth and manure as often as twice a week, or its proper protection, will largely prevent the breeding of these insects.

Habits

In its habits the fly is one of the most objectionable insects with which man comes in contact. It not only breeds in filth but it continues to frequent filthy material throughout the days of its exist-



Enlarged larvæ, showing segments. (After Howard.)

ence, leaving it to invade the residence of man, contaminate his food, and oftentimes to spread disease.

The house fly is a persistent feeder, but the feeding process itself is somewhat slow. Flies are very industrious in their search for food, even when it is right at hand, crawling over the surface thereof and evidently searching with the proboscis for more dainty morsels. On their excursions of this character they may carry with them, particularly on the hairy parts of the legs, the organisms of infectious disease, the eggs of various parasites, and organic filth. Should they next visit our tables, this dangerous material is distributed over our food. When food so contaminated is taken into the stomach, man is directly infected and may develop any one of a number of diseases.

Another manner in which flies disseminate infection is through the regurgitation or vomiting of food. It is unpleasant to consider that insects which have but recently frequented garbage heaps, cuspidors, and manure piles may be guests at our tables, but it is all the

more disgusting to consider that the very material of which they have partaken should be subsequently distributed over our own food and then received into our system. Similarly, the numerous brown excreta spots or fly specks on walls and ceilings, which are the bane of every housewife, prove by their very location that they should be far less the objects of hatred than those which are deposited elsewhere. The number of such vomited and fecal spots deposited by well-fed house flies may be enormous, frequently rising to a hundred or more a day.

The range of flight of house flies is ordinarily not great. Although in experiments they have been found as far as 13 miles from the point of their liberation, they probably seldom travel more than half a mile from their breeding place unless carried by winds, and usually remain within 200 or 300 yards of their point of origin. Therefore, if flies are found in a particular neighborhood it is fair proof that they developed in the immediate vicinity. The range of flight may be ascertained by anyone who is interested in such experiments by coloring insects with analine dyes and, following their release, recapturing them either by traps or fly paper at various distances.

Flies are attracted to houses either by the odor or presence of food. Warmth also is attractive. In cold weather they seek shelter to hibernate, crawling into unexposed places and living for several weeks in a semidormant condition. Following the onset of warmer weather they revive and become the forbears of a numerous progeny, thus continuing the race from season to season. For this reason exterminative measures are of greatest value if begun early. It is also probable that continuance through the winter season is due to the prolongation of the egg and larval stages by the low temperature. In spite of a considerable resistance to cold which flies manifest they are at the same time quite susceptible to its influence, preferring quietude to activity when so affected. Sunlight and brightness are usually attractive, a fact familiar to every housewife.

Carriers of Disease

Flies may transmit disease in either of two ways. The first method is by mechanical transference, whereby the insect becomes contaminated with the parasites or microorganisms of disease as a consequence of frequenting filth and places where these agents abound, thus carrying pathogenic organisms directly to food or drink partaken of by man. This is by far the most common method of conveyance. All forms of flies may act as disease carriers in this manner, but the house fly is the principal offending species owing to its prevalence and great tendency to frequent filth. As previously stated, the body of the fly, with its stiff, hairy parts, is well adapted to transference of contagion in this manner.

32026—25——2

Experiments have been conducted to show the length of time flies may carry the organisms of infection, but this naturally varies. If conditions are favorable, there is little doubt that bacteria may be transferred in this manner after several days. If the organisms are taken into the intestinal tract of the fly, this period may be lengthened, the feces serving as the agent of transmission and prolonging the infective stage. When it is realized that milk, which is one of the best media for the growth of bacteria, may be contaminated by flies merely through the act of feeding, the dangers of food contamination may be appreciated.

The second method of disease transmission is by inoculation; that is, the actual injection into the system by the insect of pathogenic organisms or parasites. Fortunately, disease can not be transmitted in this manner by the nonbiting flies, else our safety would be far less than at present, the bloodsucking varieties being those which are of danger in this respect. In our country these varieties are relatively infrequent. This mode of transmission is similar to that in which malaria is conveyed by mosquitoes, typhus fever by lice, and plague by fleas. The parasites or organisms derived from the blood of the infected person are received into the stomach of the fly, where they may undergo developmental changes requiring a specified period, and are subsequently inoculated into a second individual.

Of the diseases which may be transmitted by flies the following are worthy of consideration: Typhoid fever, diarrhea and enteritis, cholera, dysentery, paratyphoid fever, intestinal parasitic infections, sleeping sickness, tularæmia, surra, nagana, with a number of others where there is a distinct possibility of transference.

Typhoid fever is the most common and important infection of man conveyed by flies. It is an acute, infectious disease of bacterial origin, contracted only by taking into the system the bacteria containing discharges of one actually ill of the infection or of some person who serves as a carrier thereof. It may be contracted through sewage-polluted drinking water, infected shellfish, or in other manner, the only requisite being the presence of the typhoid bacilli in the food or drink of man. It is essentially a disease of filth, but unless means are established for the transference of such filth to the mouths of persons the infection never develops. Flies may serve as the means of this transference, and are therefore in part responsible for the dissemination of the disease. In the United States alone during 1920 over 8,000 persons died from typhoid fever, and ten times that number suffered from the infection, the rate being several times higher than that of many civilized countries.

Attention was called to the agency of flies in the transmission of typhoid fever during the Spanish American War, when hundreds of

our soldiers died from this altogether preventable infection. It appeared that the high incidence of the disease was in part due to the presence of myriads of flies which visited the unscreened and unprotected latrines, later to be accorded free access to the kitchens and dining halls of the troops, where every opportunity was available for the contamination of food. In certain instances the very chemicals used in covering discharges were found upon the bodies of the insects and occasionally upon the food itself, indicating that fecal matter was present and that infection in this manner was possible.

The conditions which prevailed during the Spanish-American War exist in thousands of American communities to-day. We look with horror upon the frightful and unnecessary sacrifice of lives which then ensued, yet within our very vision identical conditions prevail and we remain quite undisturbed. The unscreened and unprotected privy constitutes a serious menace to the health of any community. It may be the depository of typhoid excretions, and at that moment it becomes a hazard to every resident in the vicinity, for that very environment has created an insect host which may disseminate the scourge to every point of the compass. It should be understood that typhoid-fever bacilli never originate in flies themselves, but are always derived from infected human dejecta. Not only are the bacilli contained in the feces of man, but in other excretions as well. Persons actually ill of typhoid excrete enormous quantities of such organisms, but these cases may actually be of less danger than others, inasmuch as in the majority of instances proper disinfection and disposal of such material are secured. Many persons, however, continue to excrete these dangerous organisms long after they are well, in some instances for years, and thus are a constant source of danger to the public. So common is this condition that at least 2 per cent of those who have recovered from the disease can be rated as typhoid-bacillus carriers. Again, walking or ambulant cases of typhoid may occur, and in certain instances the condition goes unrecognized or is mistaken for something else, so that necessarily there is, and will continue to be, serious danger through the medium of flies from these apparently harmless persons.

Food purchased in fly-ridden markets may likewise be a source of contamination, and if eaten uncooked may lead directly to illness. Cooked food of whatever nature may be contaminated subsequent to the cooking, constituting a serious menace to health. Irrespective, then, of the precautions we exercise as individuals, we are all more or less exposed to the infection of typhoid fever through common sources. Further, as a result of the laxity of others, even when we ourselves may have exercised every precaution necessary to prevent the development of flies, our lives are frequently endangered.

A second infection, and one analogous to typhoid, frequently conveyed by flies, is summer diarrhea. This is more particularly a disease of children, but adults are also susceptible. Annually in the United States 70,000 infants under 2 years of age die from diarrhea and enteritis, the infectious nature of which has now been definitely determined. Bacteria of various varieties are known to be responsible for the disease. The sources of infection are much the same as in typhoid, the causative organisms reaching the alimentary tract as a result of uncleanliness, infected food, and very possibly by contamination of hands or food through the activities of flies. The evidence against the fly as a conveyer of the infection is largely circumstantial, yet so conclusive is it that no one would fail to place part of the responsibility on this insect.

First, the disease exists in the summer season, when flies are known to be prevalent. Its incidence varies directly with the incidence of flies, the summer diarrhea curve and the fly curve practically coinciding. This in itself is suggestive. Further, it has been demonstrated that flies are important distributors of bacteria, that they frequent localities where infected organisms are deposited, and that following eradicative measures directed toward these insects there is almost invariably a decrease in the prevalence of intestinal complaints of this character. It would therefore seem that in the light of our present knowledge we are warranted in the conclusion that flies play a definite rôle in the dissemination of the disease. If we wish, then, to save the lives of the babies, the very first step in the process is the eradification of flies.

Cholera and dysentery, which are primarily intestinal affections, conveyed in the same manner as typhoid, may be at times disseminated by flies. Each is a bacterial disease due to a specific organism, the development of which follows the ingestion of water or food contaminated in some way from the discharges of a person ill with the disease or who excretes the bacilli thereof. It is reasonable to suppose that in a certain percentage of cases flies may act as the distributing agent, and this has been well established with the first-mentioned infection. Fortunately cholera is a rare affliction in this country, originating only from imported cases, but epidemics of dysentery are not uncommon, being especially prevalent in institutions, camps, and districts where insanitary conditions prevail.

In addition to the intestinal diseases cited, certain other affections, more or less closely related thereto, may at times develop as a result of the activities of flies. Paratyphoid, a first cousin of typhoid fever, and one type of food poisoning is to be considered in this category.

A most interesting disease in which it is clearly established that flies act as the sole agent of transmission is African sleeping sickness, this being an example of conveyance by inoculation. The in-

fection is due to the invasion of the blood and body fluids by a parasite known as a trypanosome, which lives and multiplies after it has once been introduced. Analogous parasites exist in the bodies of mammals other than man. Rats, for example, are frequently found to harbor a species of trypanosome, but curiously no symptoms develop. In this case the rat flea or rat louse is supposed to be the agent of transmission. A second variety of trypanosomes inhabits the blood of horses and other domesticated animals, producing a disease known as surra, an infection of serious economic importance in Asia, the Philippines, and other tropical countries. For many years the natives of India have ascribed the disease to the bites of insects, and at present it is all the more probable that certain species of blood-sucking flies are the responsible agents. Still another variety of trypanosome is seen in the horses, cattle, and domesticated animals of Africa. The disease as manifested in horses is known as nagana, and infected animals either die suddenly or are rendered useless to their owners as a result of deterioration through emaciation or weakness. Nagana is known to be transmitted by various species of biting flies.

In man sleeping sickness, or trypanosomiasis, is a slowly fatal infection, recovery being very rare. The disease affects the natives of certain districts of central Africa, entire areas having been depopulated as a consequence of its ravages. The insect transmitter is a species of biting fly known as the tse tse fly, which inhabits the shores of lakes and streams in that locality. Upon biting an infected person the insect absorbs the parasites, which then undergo certain changes within the body of the fly, and are subsequently inoculated into healthy persons, who, after a prolonged illness, ultimately die of the infection.

In addition to the disease cited there are numerous other conditions where the possibility of fly transmission has at least been considered, although definite proof has been difficult to obtain of the truth of the theories advanced. In the majority of such conditions infective secretions capable of being transferred through the action of flies, either directly or through the medium of food, to healthy persons, are present. Tuberculosis may be mentioned as an example of such condition. Access to tuberculous sputum by flies is not only disgusting from an æsthetic standpoint but, potentially, at least, fraught with danger. The infectious disease of the eyes, trachoma, particularly as seen in Egypt, may be conveyed at times by these insects. Tropical sore, a serious and mutilating ulcerative disease occurring in various sections of South America, is not improbably disseminated by flies, and it is also believed that yaws, a somewhat similar disfiguring disease accompanied by infective secretions, may at times be spread in this manner. Mention should also be made

of anthrax, which only occasionally affects man, but is rapidly fatal to cattle and sheep, and therefore of importance to the farmer. The spores of this organism are extremely difficult to kill, and it is believed that they may live in the intestinal tract of flies for days, to be later inoculated into healthy stock through the avenue of open sores or abrasions. Still another infectious disease propagated through the agency of flies is phlebotomous fever, found only in districts where sand flies abound, and due directly to their bite.

Before the subject of disease transmission by flies is dismissed, a remaining condition should be mentioned. This is myiasis, or, in other words, the invasion of wounds, body cavities, or the alimentary tract of man or animals by the larval forms of any species of fly. This condition, while rare where the ordinary rules of cleanliness are observed, is not at all unusual among those of filthy habits or those who are subject to neglect, more especially the residents of tropical countries. Of the cavities selected the ears and nose, particularly if abnormal secretions are present, are most apt to be the sites involved. Sleeping in exposed places accessible to insects predisposes to the condition. Neglected wounds, if accompanied by purulent discharges, may be the seat of lesions resulting from the activities of larvæ developing from eggs deposited by the female fly. In the same manner larvæ may develop in the alimentary tract of animals, and even of man, causing not only uncomfortable but serious symptoms. There are certain flies of which a portion of the developmental cycle is ordinarily passed in the alimentary tract of animals, the eggs being deposited upon the hair. Upon the development of the larvæ a slight amount of irritation results, which causes the animal to lick the spot, thus introducing the larvæe into the stomach, where they attach themselves to the muscous membrane until they are ready for pupation.

Enemies of Flies

Before consideration is given to the subject of fly control, brief mention should be made of the natural enemies of flies and the diseases from which they suffer, inasmuch as the number of insects is frequently affected through the operation of such cases. Unfortunately the natural enemies are few and those which do exist are scarcely under the control of man. Among the enemies to be mentioned are lizards, toads, spiders, certain species of wasps, and robber flies, all of which devour flies whenever they approach within reach. The lizards and toads are particularly good flycatchers, but naturally the combined effect of all these enemies upon the total fly population is almost negligible. The enemies of the larvæ are, however, much more successful in their inroads. First place should, of course, be given to the birds, which eagerly devour both the larval and adult

forms. The scratching barnyard fowl is a worthy enemy, and certain forms of beetles and ants also feed industriously on both larvæ and pupæ of nearly all varieties. On the whole, the natural enemies of both the larval and adult forms fail to effect an appreciable reduction in the fly population.

The diseases of the fly family are seemingly much more deadly, but here again man is unable to take advantage of their presence. There are a number of parasites which are probably annoying to their hosts, but not especially destructive, and there are also certain mites which attach themselves to flies for migratory purposes. These are merely of scientific interest.

Adult flies are subject to at least one disease which makes serious inroads upon the insect population. Probably most of us have noticed late in the summer season dead-house flies attached to ceilings or articles of furniture. Upon close inspection they may be found to have a whitish discoloration upon the abdomen or the entire fabric of the fly may appear to be disintegrated. The white material observed is the remains of a fungus known as the house-fly fungus or empusa. The fungus is more frequently observed in insects which have adopted an indoor life, but it also attacks those living under outside conditions. The disease is probably derived from insects similarly affected and first invades the body through either minute openings or the respiratory channels, gradually encroaching upon and destroying the internal organs and causing death within a few weeks of its appearance. The infection is especially prevalent from August to October and accounts, in large part, for the great reduction in the number of flies during the latter part of the season, literally millions of insects being destroyed at this period. It is a matter of regret that the disease does not manifest itself earlier in the season and that it is a condition as yet beyond the control of man, otherwise the fly problem might be capable of easy solution.

Eradicative Measures

The most successful method of ridding a community of flies is to institute a continued campaign for that purpose. It is only by the united efforts of all residents, supplemented by the support of the health department and civic organizations in general, that progress in fly eradication is possible. This does not mean that individual effort is to be entirely subordinated or submerged, or that cleanliness of single premises is not of value, but only that the problem should be attacked as a whole and that the united effort of every citizen is necessary for its solution.

The time of the year has an important bearing upon the success of such a movement. Ordinarily fly-eradicative campaigns are instituted too late in the season to be effective. The best results are ob-

tained if the work is begun in April, or in southern latitudes even in March, and not postponed until the natural increase in the fly population renders eradicative measures futile. The chances of success of any campaign diminish rapidly as the summer months pass. Fly prevention is much more successful than fly eradication, and this aspect of the question should constantly be borne in mind.

Of the measures to be recommended, those which aim to control the development of the larvæ hold first rank, while those instituted against adult flies are usually far less successful. As long as fly-breeding areas exist it is useless to undertake suppressive measure of other character; therefore effectual control of these places is the first requisite. This means that the highest standards of community cleanliness must prevail, that accumulations of refuse and rubbish must be avoided, and that proper disposal of garbage and waste must be provided. When it is realized that even small amounts of material of this nature may serve for the development of innumerable larvæ, the importance of its removal can be realized.

As horse manure constitutes the favorite breeding place for flies, its protection from adult insects is essential. Provision should be made in stables for its reception in either closed or screened bins, preferably the former. These bins should be made of cement or wood and should be properly drained in order to avoid the development of unpleasant odors. Where a small amount of manure is handled covered cans may be used. For large manure heaps the form of larval trap consisting of a raised platform a foot or more in height, covered only with slats, has been recommended. Beneath the platform is a concrete tank, holding about 2 inches of water, with plugged inflow and outflow pipes. The manure is placed on the slats and is entirely accessible to flies, but when the larvæ reach the migratory stage they leave the manure, fall into the water, and are drowned. The cement basin should be flushed out at least twice a week for purposes of cleanliness and to prevent the breeding of mosquitoes, and the manure should be kept fairly moist. It is estimated that fully 99 per cent of the developing larvæ may be killed in this manner.

On the farm the problem of manure disposal is not at all simple. Accumulations of animal excreta are largely unavoidable and flies even may breed in manure distributed on the soil for fertilizing purposes, although if the material is well pulverized this is less likely to occur. Where it is impossible to properly protect manure piles, treatment with certain vegetable and chemical products, with the idea of destroying both the eggs and larvæ, is to be recommended. Of such substances borax is probably the best, applied

either in solution or sprinkled over the manure and then moistened with water. The development of both the eggs and the larvæ is inhibited. Unfortunately, the borax contained in manure so treated may injure certain soils, especially if used in an excessive amount; therefore the quantity should not be too liberal. The Department of Agriculture estimates that if the amount does not exceed 1 pound to every 16 cubic feet of manure and that if not more than 15 tons of the treated material is applied to the acre no damage will result. There are a number of other substances adapted to this same purpose. Chloride of lime, or bleaching powder, if applied in liberal quantities, not only prevents access of flies but also the development of the larvæ. However, it is directly injurious to the manure, as it interferes with its fertilizing power. If used, the dry powder should be sprinkled upon the mass. Hellebore, also used for the destruction of potato bugs, is fairly efficient.

For every bushel of manure an ounce of the powder should be mixed with 1 gallon of water, and after standing for a day or two sprinkled on the pile. Another substance which has been used with beneficial results is sulphate of iron, 2 pounds per gallon of water, this being sufficient to properly treat the manure from one horse for a day. Kerosene, which has had extensive use for this purpose, has but little effect upon the fly larvæ and is decidedly injurious to the manure.

If manure can neither be protected nor treated, its frequent removal becomes necessary. Under ordinary conditions the entire life cycle of the fly occupies only eight or nine days, but from the time the egg is deposited until the larval migratory stage is reached but four days are required. For this reason it is essential that the manure be removed at least every four days if fly breeding is to be prevented. The same rule applies to collections of refuse, organic waste, decaying vegetable matter, and street sweepings. If material of this nature remains exposed for a longer period than four days it becomes a breeding spot for flies. Its removal and early destruction are therefore to be urged. While fairly good results may attend the treatment of organic wastes and refuse in a similar manner as that recommended for manure, it would be quite unwise to adopt such a course when more practicable measures are at hand.

Next to stable manure the outhouse or privy of rural communities deserves attention. House flies which develop in or frequent human excrement are many times more dangerous than those which frequent other filthy areas; therefore every effort should be made to eliminate this particular source of flies. Fortunately this is not a difficult procedure. While many types of sanitary privies have been

devised (see Public Health Bulletins Nos. 51 and 68), all should have the one common provision of preventing the ingress of insects. This is best accomplished by screening. Every aperture should be thoroughly protected in this manner, and if openings exist either in the masonary or woodwork they should be closed. The seat should be self-closing; and if ventilating openings are present in the receptacle or other portion, they should be properly screened. The same principles apply to latrines in camps or wherever human excrement is deposited.

The proper disposal of garbage has been already referred to. It is best that all household refuse be kept in water-tight metal cans having accurately fitting lids, not only to prevent access of flies but of other vermin as well. Collections of rubbish about the yard are responsible for much of the fly breeding, and public dumps may also constitute a prolific source of these insects. If these accumulations are permitted, fly breeding is inevitable.

Of the measures directed against adult flies, screening is most suitable. The unscreened house and the unprotected privy constitute a menace which no family should tolerate. It is, of course, well recognized that screens do not keep out all flies; but if the screening is properly done, certainly 95 per cent of flies are prevented from entering and the danger is therefore reduced by just that percentage. If the owner is unable to protect the entire house in this manner, the lower floor should be given the preference, principally because flies are most numerous at that level, and it is the place where food is prepared. If not more than one or two rooms are to be screened, the kitchen and dining room should be selected. In the case of sickness the sick room should by all means be protected, particularly if the disease is infectious, and in farming communities the dairy should receive similar attention. For persons sleeping out of doors where flies abound, screening is advisable. It is also just as necessary that flies should not have access to markets, bakeries, and other places where food products are exposed. Whenever screening is instituted it should serve the double purpose of keeping out mosquitoes as well as flies, therefore a No. 16 mesh wire should be employed.

The devices for ridding rooms of flies are many, varying from traps, poisons, and papers to fumigation. Most of these procedures are objectionable in one way or another and many are ineffective. The most common form of trap is the conical or cuboidal wire-gauze affair, baited with saccharine substances and arranged in such a manner that the insect passes through a small opening into a large space from which he is unable to emerge. As traps go, they are generally effective, but flies, like all other animals, are often reluctant to enter places from which they can not escape.

Of substances poisonous to flies, formalin is perhaps most useful. It should be diluted with about 40 parts of water and placed in saucers about the room, at the same time removing all other liquids. After being denied all fluids for several hours the flies will drink the formalin solution and die, but the success of the plan is wholly dependent upon the complete removal of other liquids. A modification of this plan is to make the dilution with milk, placing a piece of bread in the saucer on which the flies may alight.

A fly poison about equal in efficiency to the formalin solution mentioned above can be prepared with sodium salicylate. A solution should be made by adding three teaspoonfuls of sodium salicylate (a powder) to a pint of water. As this solution is somewhat repellant to flies, three tablespoonfuls of brown sugar should be added.

A convenient container that will automatically keep the solution available for flies to drink may be easily made. A thin-walled drinking glass is half filled with the liquid poison. A saucer or small plate in which has been placed a piece of white blotting paper cut the size of the dish, is put bottom up over the glass. The whole is then quickly inverted, a match placed under the edge of the glass, and the container is ready for use. As the solution dries out of the saucer more liquid flows into the dish, always keeping the paper moist.

Of other fly poisons mention should be made, merely for the purpose of condemnation, of those composed of arsenic. Fatal cases of the poisoning of children through the use of such compounds are far too frequent, and owing to the resemblance of arsenical poisoning to summer diarrhea and cholera infantum, it is believed that the cases reported do not by any means comprise the total. Arsenical fly-destroying devices must therefore be rated as extremely dangerous and should never be used, even if other measures are not at hand.

Sticky fly papers may serve a useful purpose. Fumigation with sulphur dioxide gas, generated by burning ordinary brimstone, is a valuable insecticidal measure, but unfortunately is injurious to fabrics and to painted and other surfaces. The sulphur should be used in quantities not less than 1 pound per 1,000 cubic feet of space, moistened with alcohol, and ignited, care being taken that the metal container is placed in a pan of water. Pyrethrum, or insect powder, may also be burned, but it is expensive and only temporarily stupifies the insects.

Fly-swatting campaigns, of themselves, are not sufficient for the elimination of flies. Usually they are inaugurated only at the height of the fly season when a perceptible diminution in the number of insects present is not possible. If instituted during the early spring months, when the insects from which the millions of others are to be

derived are few in number, some benefit may follow, particularly if precautionary measures are also exercised in regard to breeding places. If the energy displayed in late season fly-killing campaigns could only be directed into proper channels during the early spring months, and if the people would realize that strict cleanliness and the immediate destruction of all filth and garbage are essential throughout the year, the fly problem would be largely solved.

○